Sub-Optical Lithography With Nanometer Definition Masks

Frank T. Hartley	Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA. E-mail: Frank.T.Hartley@jpl.nasa.gov
Chantal Khan Malek	Center for Advanced Microstructures and Devices (CAMD) Louisiana State University
Jayant Neogi	Norsam Technology

A poster would be preferred.

Nanometer feature size lithography represents a major paradigm shift for the electronics and micro-electro-mechanical industries. In this paper, we discuss the capacity of dynamic focused reactive ion beam (FIB) etching systems to undertake direct and highly anisotropic erosion of thick evaporated gold coatings on boron-doped silicon X-ray mask membranes. FIB offers a new level of flexibility in micro fabrication, allowing for fast fabrication of X-ray masks, where pattern definition and surface alteration are combined in the same step which eliminates the whole lithographic process, in particular resist, resist development, electro-deposition and resist removal. Focused ion beam diameters as small as 7 nm can be obtained enabling fabrication well into the sub-20 nm regime.

In preliminary demonstrations of this X-ray mask fabrication technique 22 nm width lines were milled directly through 0.9 μm of gold (Figure 1) and a miniature mass spectrometer pattern was milled through over 0.5 μm of gold (Figure 2). Also presented are the results of the shadow printing, using the large depth of field of synchrotron high energy parallel X-ray beam, of these and other sub-optical defined patterns in photoresist conformally coated over surfaces of extreme topographical variation.

Assuming that electronic circuits and/or micro devices scale proportionally, the surface area of devices processed with X-ray lithography and 20 nm critical dimension X-ray masks would be 0.5% that of contemporary devices (350 nm CD). The 20 CD mask fabrication represents an initial effort - a further factor of three reduction is anticipated which represents a further order-of-magnitude reduction in die area.

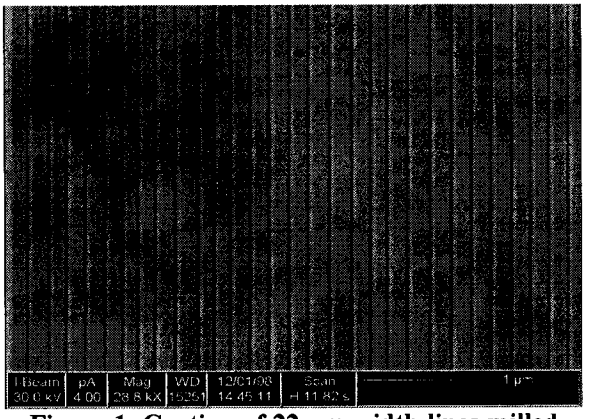

Figure 1. Grating of 22 nm width lines milled directly in 0.9 μm of Au.

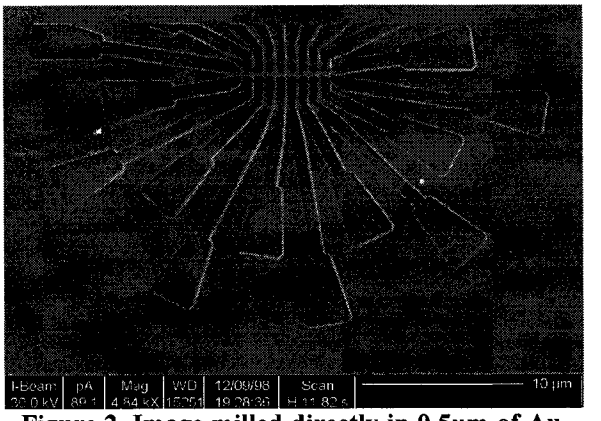

Figure 2. Image milled directly in 0.5μm of Au.